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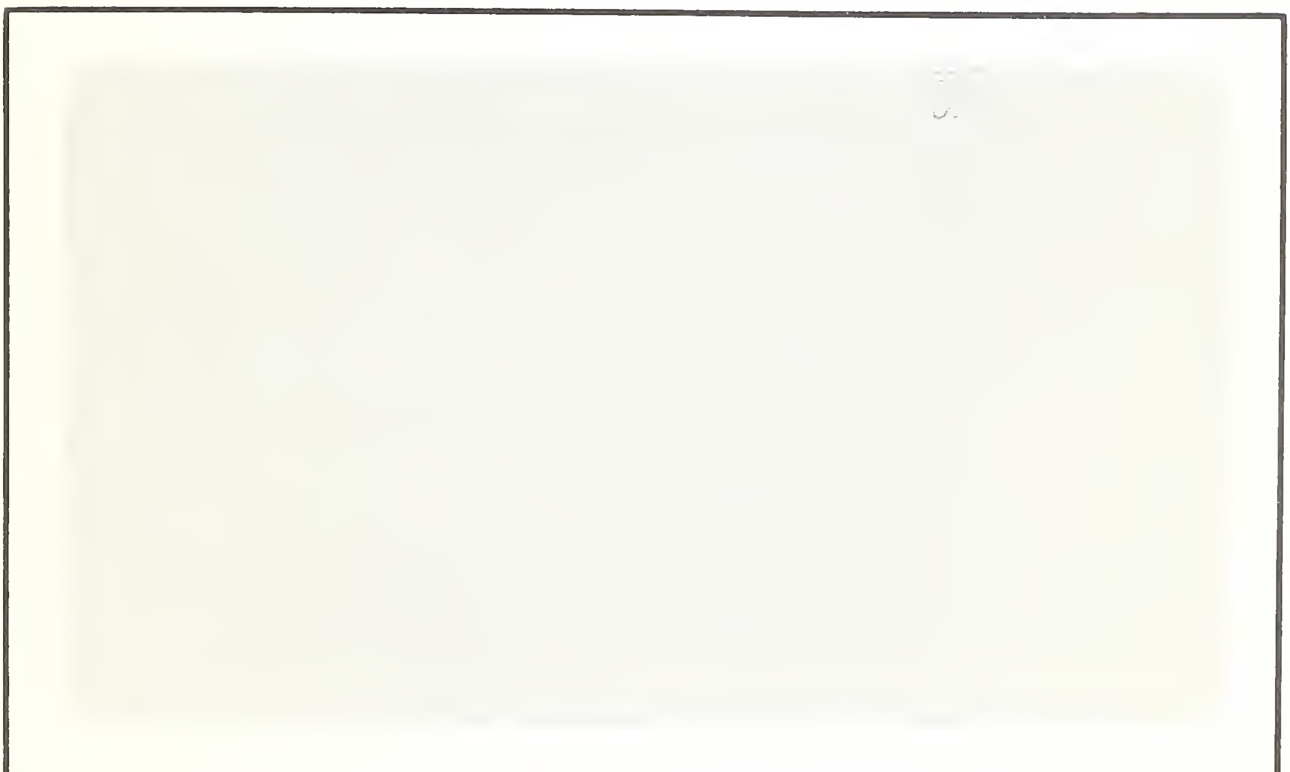
Dryland Cropping Practices in the Southern Great Plains



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Dryland Cropping Practices in the Southern Great Plains

By Ordie R. Jones and Wendell C. Johnson[1]

ABSTRACT

Practices currently used in producing dryland winter wheat, cotton, and grain sorghum are discussed in detail. Included are areas of adaptation, soil fertility, water requirements, and tillage and other cultural practices. Also given are cropping practices for cultivated forages, sunflowers, and guar, along with cropping sequences used to produce adapted crops. Promising research developments discussed are adoption of no tillage and limited tillage in lieu of conventional tillage; reduction of storm runoff and subsequent soil erosion by land-leveling, terracing, and furrow-diking; and integration of irrigated and dryland cropping practices so that residues from irrigated crops are utilized to conserve soil and water for dryland crop production. Index terms: cotton, *Cyamopsis tetragonoloba* (L.) Taub., dryland farming, forages, *Gossypium hirsutum* L., grain sorghum, guar, *Helianthus annuus* L., *Sorghum bicolor* (L.) Moench, Southern Great Plains, sunflowers, *Triticum aestivum* L., winter wheat.

INTRODUCTION

Research on dryland crops and cropping sequences has been conducted at various locations throughout the Southern Great Plains. Results have shown that only a limited number of crops can be produced profitably on dry land in the area (Daniel and Finnell 1939, Harvey et al. 1961, Keating and Mathews 1957, Mathews and Barnes 1940). The major adapted crops are winter wheat, *Triticum aestivum* L.; grain sorghum, *Sorghum bicolor* (L.) Moench; and upland cotton, *Gossypium hirsutum* L. Grown to a lesser extent are forages of various types; sunflowers, *Helianthus annuus* L.; and guar, *Cyamopsis tetragonoloba* (L.) Taub. Cropping practices and systems employed to produce these crops in the Southern High Plains, Rolling Red Plains, and Reddish Prairie land-resource areas of the Southern Great Plains are discussed below.

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CROPS

Winter Wheat

General cropping practices

The distribution of and area occupied by winter wheat in 1978 are shown in figure 1. Most wheat in the Rolling Red Plains and Reddish Prairie is cropped annually. In the Southern High Plains and particularly in the Oklahoma

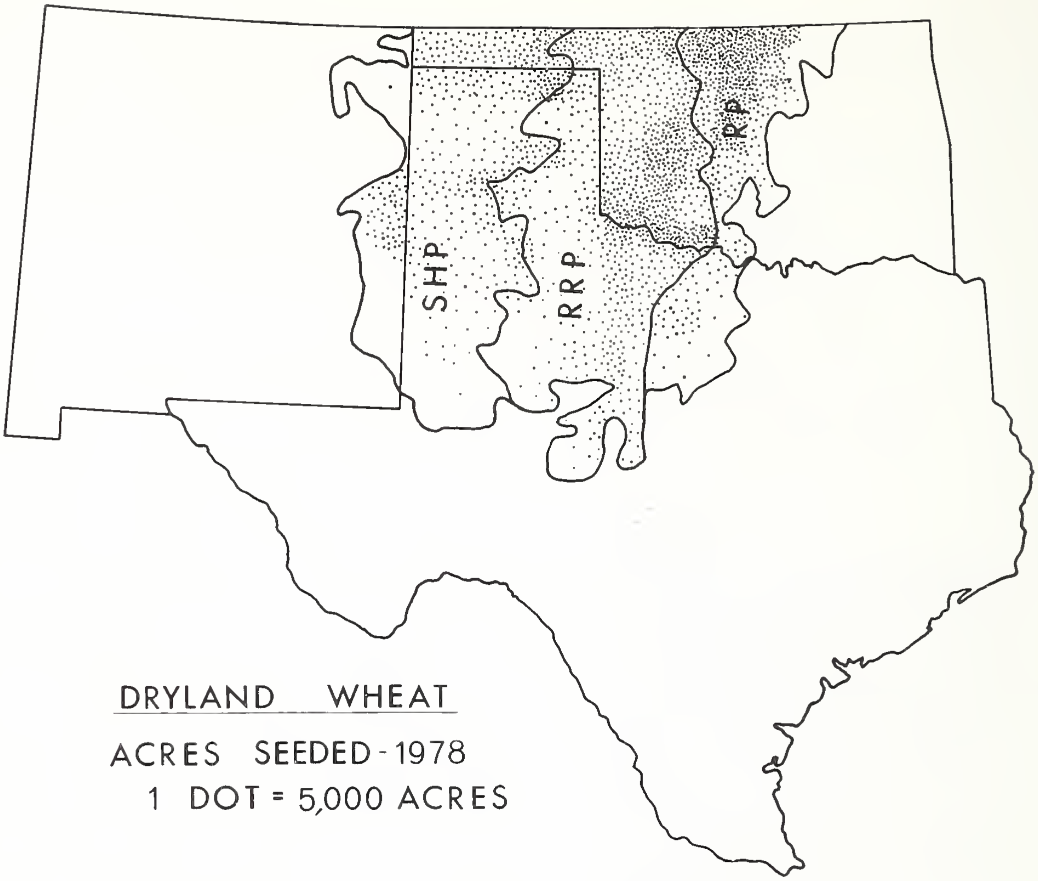

FIGURE 1.—Distribution of dryland wheat in the Southern High Plains (SHP), Rolling Red Plains (RRP), and Reddish Prairie (RP) land-resource areas of the Southern Great Plains. (Drawn from data supplied by Crop and Livestock reporting services of Texas, Oklahoma, and New Mexico.)

Panhandle, 40 to 50 percent of the wheat is grown in an alternating crop and fallow sequence commonly referred to as "summer fallowing." Compared to continuous cropping, summer fallowing reduces total grain production in all areas of the Southern Great Plains; however, in the drier western area fallowing greatly decreases the probability of crop failure. At Bushland, Tex., with average annual precipitation of 18.5 inches, average wheat yields (1942-70) were 10 bushels per acre for continuous wheat and 15 bushels per acre for wheat grown on summer fallow; thus, fallowing increased yield per harvested acre by 50 percent. The probability of producing 15 bushels per acre of wheat was 0.50 for summer fallow and only 0.25 for continuous cropping (Johnson et al. 1974). Summer fallowing on Pratt fine sandy loam (sandy, mixed, thermic Psammentic Haplustalfs) at Woodward, Okla., with average rainfall of 23.8 inches per year, increased yield only 28 percent (17 to 22 bushels per acre) in comparison with continuous cropping (Locke and Mathews 1953). Thus, summer fallowing is not recommended on the Rolling Red Plains and Reddish Prairie because yields are not increased sufficiently by fallowing, and the soil erosion hazard is increased during the 15-month fallowing period, even when stubble-mulch tillage is used (Johnson et al. 1974).

Winter wheat is produced on most soils in the Southern Great Plains. The largest wheat areas are on fine-textured soils such as loams and clay loams. With larger water-holding capacities, these soils produce greater yields than sandier soils during favorable years. However, during dry years there are fewer crop failures on coarser soils, and yields are better than on fine-textured soils (Mathews and Brown 1938). In marginal rainfall areas, as in the Southern High Plains land-resource area, coarse-textured soils such as sands and sandy loams are subject

to severe wind erosion, making it difficult to establish and maintain stands of wheat.

Yields of continuous wheat increase from west to east across the Southern Great Plains in response to increasing precipitation. Yields average 10 bushels per acre at Bushland, Tex. (Johnson et al. 1974), and Goodwell, Okla. (H. E. Reeves, personal communication), and increase to 17 bushels per acre at Woodward, Okla. (Locke and Mathews 1953), and 26 bushels per acre in Garfield County in north central Oklahoma. In the Reddish Prairie of Oklahoma, sometimes called the "breadbox" of Oklahoma, 80 to 90 percent of all cultivated land is continuously cropped to wheat, with average county yields ranging from 20 to 30 bushels per acre (D. M. Fain, personal communication). It should be noted that in the drier areas (Southern High Plains land-resource area) commercial fertilizers are not normally required because water is the factor that limits yield, but in the Rolling Red Plains and Reddish Prairie both nitrogen and phosphorus are necessary because nutrient supply rather than water often limits yield.

Continuous annual cropping of land to one crop is not a generally recommended practice. Problems may develop with weeds, diseases, insects, and soil fertility (Arnon 1972). However, continuous cropping of winter wheat is not objectionable, except possibly with respect to weed control. At Stillwater, Okla., wheat has been continuously grown on the same plot of land since 1893. Organic matter and nitrogen in the topsoil have gradually decreased, but the average yield has not declined appreciably, even where no fertilizer has been applied. Unfertilized wheat has averaged 14.6 bushels per acre, and manured treatments have averaged 23.1 bushels per acre. A similar yield increase in response to the addition of commercial fertilizer indicates that soil fertility rather than water is the primary factor limiting wheat production in the Reddish Prairie (Harper 1959, Webb et al. 1980).

Current fertilizer recommendations for wheat grown in the Reddish Prairie of Oklahoma are based on a minimum requirement of 100 pounds per acre of nitrogen, 30 pounds per acre of phosphorus, and 200 pounds per acre of potassium. Normally, only nitrogen and phosphorus are added, since sufficient potassium is usually present in the soil. Since most wheat grown in Oklahoma is grazed, additional fertilizer beyond the requirement for grain production should be applied.

Seeding date

The optimum time to seed winter wheat in the Southern Great Plains varies among years. In the Rolling Red and Southern High Plains, highest grain yields can be expected when wheat is seeded from about September 20 to October 10 (Porter et al. 1952). Highest grain yields in the Reddish Prairie result from seeding in mid to late October. Winter wheat, however, can be seeded from late August until mid-November. Major factors determining seeding date are soil-water supply, diseases, and whether or not the wheat will be grazed. Early seeding of wheat (August 20 to September 10) has the advantages of providing forage for grazing and reducing the wind erosion hazard, but it has several disadvantages. Early seeding of wheat, followed by warm weather, may subject plants to infections by root rot, *Helminthosporium sativum* P., K., & B., particularly in southern parts of the Rolling Red Plains and the Reddish Prairie. Early seeding encourages heavy growth of plants that may suffer winter injury unless grazed. Heavy growth also depletes soil-water reserves, making the plants totally dependent on precipitation to sustain spring growth. Late seeding (late October to mid-November) may result in poorly tillered, shallow-rooted plants that are subject to winter injury. Winter wheat seedlings in the three- to four-leaf stage survive cold temperatures better than more developed plants or those in the one- to two-leaf stage (Schlehuber and Tucker 1967).

Seedbed preparation

Stubble-mulch tillage is used by many farm operators to maintain crop residues on the surface for protection against soil erosion and for increased water storage. The initial tillage after harvest should be the deepest, with subsequent operations at shallower depths. Chisel plows or stubble-mulch sweep plows with large V-shaped blades (fig. 2) are used in initial operations at depths of about 5 inches, with subsequent operations at 2- to 4-inch depths. Tillage should only be used as often as required to control weeds. Shallow tillage with V-shaped blades or rod weeders should be performed immediately

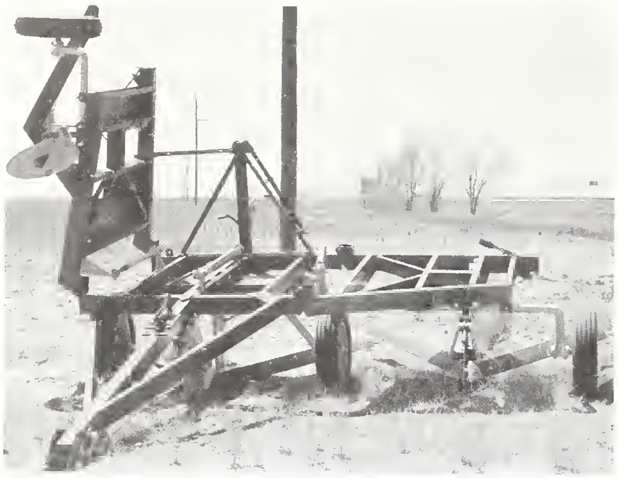

FIGURE 2.—Stubble-mulch sweep plow with large V-shaped blades.

before seeding to eliminate weeds and compact the seedbed to aid in seedling establishment.

After harvesting of wheat crops with large amounts of residue (2,800–3,000 pounds per acre) in the Rolling Red Plains and Reddish Prairie of Oklahoma, the initial operation is offset disking with subsequent operations with V-shaped blades. A problem with cheat, *Bromus secalinus* (L.), has developed in the Reddish Prairie of Oklahoma. Inversion of the soil profile with moldboard plows to depths of 8 to 10 inches at 4-year intervals is recommended for cheat control (D. M. Fain, personal communication).

Seeding rates and equipment

Seeding rates should be adjusted according to seeding date, water supply, location, and ultimate use of the wheat (grazing, grain, or both). The predominant factor is the amount of water available for production. In the drier Southern High Plains land-resource area, a seeding rate of 30 pounds per acre is adequate; whereas in the Reddish Prairie, rates of 40 to 75 pounds per acre are recommended. Rates should be increased slightly for late seeding or where the wheat will be grazed.

Two basic types of grain drills are used in seeding wheat—disk drills and deep-furrow hoe drills. Both types are used throughout the Southern Great Plains. Disk drills, with single- or double-disk openers, are used to seed smooth, well-prepared seedbeds that have little or no crop residue on the surface. Row spacings range from 8 to 14 inches. Narrow spacings are commonly used in the eastern or higher rainfall areas, and wider spacings are used in dry areas.

High-clearance deep-furrow hoe drills, with row spacings of 10 to 14 inches, are adapted to seeding in drier soils and in stubble-mulch residues. These drills have a hoe or shovel-type opener that can penetrate dry surface layers and place seed into moist soil. A press wheel in each furrow firms the soil to aid germination. The resulting furrow provides protection to emerging seedlings from blowing soil.

COTTON

General cropping practices

Distribution of dryland cotton in the Southern Great Plains is shown in figure 3. The northern limit of production parallels the 210-day frost-free line. Most cotton is grown on deep, coarse-textured soils in the Southern High Plains and Rolling Red Plains land-resource areas. Most dryland cotton is of the upland type grown for once-over stripper harvesting. Cotton is drought resistant, and its deep root system enables it to produce some lint yield even under adverse soil-water conditions. Cotton responds well to increased soil-water content at planting (Burnett and Fisher 1954), but yields are not increased sufficiently by fallowing to make the practice profitable (Keating and Mathews 1957). Thus, cotton is grown continuously or in rotation with sorghum or wheat.

Nearly all cotton grown in areas with less than 22 inches average annual precipitation is grown in a skip-row planting system. Common systems are—two rows planted and two rows skipped, two rows planted and one row skipped, and four rows planted and two rows skipped. Skip-row planting of cotton is a holdover practice that developed when acreage limitations were imposed a number of years ago. Highest per acre yields are usually obtained from planting every row. However, yield decreases due to skip-row planting are not large (table 1). Skip-row planting has the following advantages over solid-row planting:

1. Lower production costs because fewer seed are planted and the harvested area is smaller.
2. Weed control is easier.

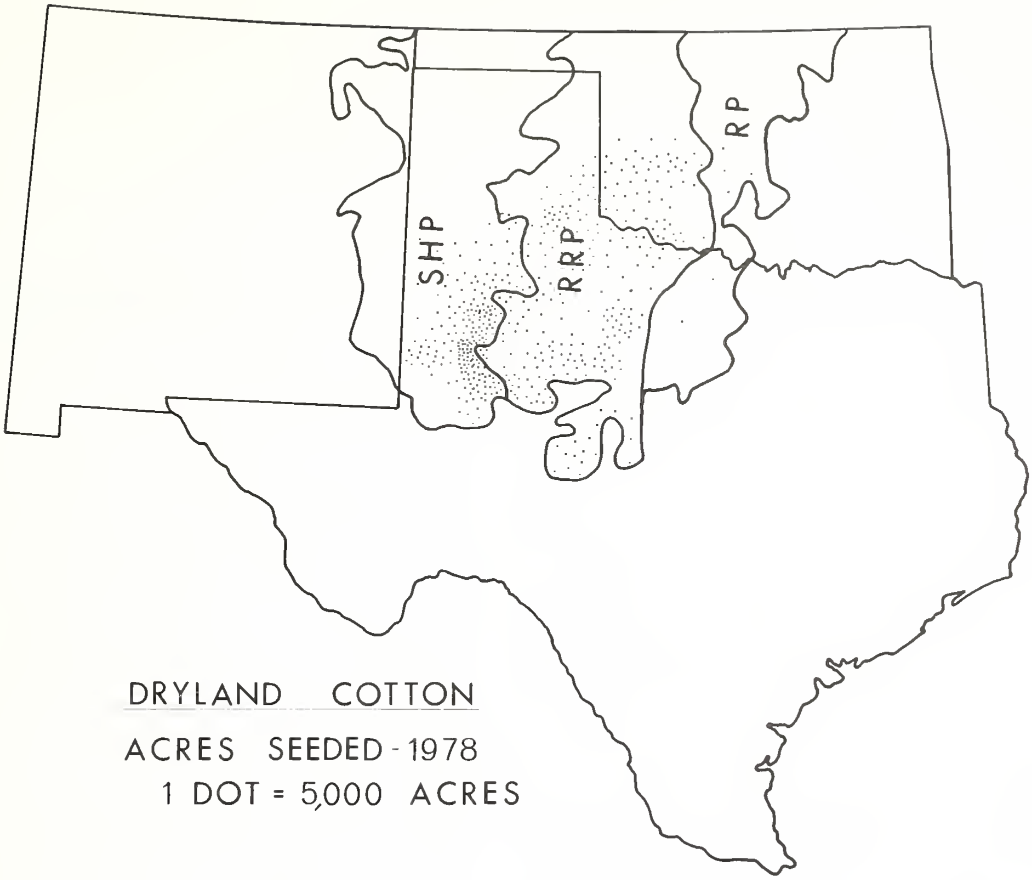

FIGURE 3.—Distribution of dryland cotton in the Southern High Plains (SHP), Rolling Red Plains (RRP), and Reddish Prairie (RP) land-resource areas of the Southern Great Plains. (Drawn from data supplied by Crop and Livestock reporting services of Texas, Oklahoma, and New Mexico.)

Table 1.—Average yield, in pounds per acre, for cotton planted in every row and in skip rows[1]

Cropping system	Chillicothe 1965-67[2]	Lubbock 1963-65[3]	Big Spring 1958-62[4]	Spur 1930-43[5]
Every row planted	239	175	258	267
Skip-row planted:				
1 planted-1 skipped	.....	.....	260	250
2 planted-1 skipped	260	147	253	254
2 planted-2 skipped	250	159	232	.....
4 planted-4 skipped	260	.....	204	.....

[1]All four locations are in Texas. Cotton was seeded in 40-inch rows.
[2]Mulkey (1968).
[3]Newman (1967).
[4]Burnett and Welch (1966).
[5]P. T. Marion, unpublished data.

3. Wheel traffic is concentrated in the skipped rows, resulting in less compaction near planted rows.

4. High residue crops can be seeded in the skipped rows to provide barriers for wind erosion protection. This is not a common practice because yield of cotton, the high-value crop, is often reduced; however, Fryrear (1976) has shown that this is a desirable conservation practice on sandy soils in the Southern High Plains.

Weed control in cotton has undergone a quiet revolution since trifluralin and nitralin (see appendix for trade and chemical names of herbicides) were shown to be effective preplant herbicides (Wiese et al. 1969). Nearly all cotton grown in the Southern Great Plains is treated with preplant or preemergence herbicides for weed control. Additionally, Johnsongrass, *Sorghum halepense* (L.) Pers., in cotton is controlled by postplant treatment with glyphosate using a recirculating sprayer or a rope-wick applicator.

Seeding date

Short growing seasons often limit cotton lint yields in the Southern Great Plains, particularly in the Southern High Plains. It is important to seed as early as is practical in the spring to obtain the longest growing period possible. However, seeding too early, when soil temperatures are low, results in poor emergence, increased incidence of root and seedling diseases, and slowed seeding development. As a guide, Elliot et al. (1968) suggested delaying seeding until the minimum soil temperature at the 8-inch depth in the bed averages 64° F for 10 days. In the Southern High Plains at Lubbock, Tex., this normally occurs from May 1–10. Yields of cotton seeded after about June 1 begin to decrease, and the latest practical seeding date in the Southern High Plains is about June 10. In the Rolling Red Plains, where the growing season is longer, most cotton is seeded between May 15 and June 1. Later seeding may result in increased damage to cotton squares and bolls from the boll weevil, *Anthonomus grandis* Boheman, because boll weevil populations increase as the growing season progresses (Rogers et al. 1976). Cotton often must be reseeded because intense rainfall causes soil crusting, which reduces seedling emergence, or because seedlings are destroyed by blowing soil or by hail.

Seedbed preparation

Land preparation normally begins in February or March. Residues from the previous crop are shredded, and the land is moldboard-plowed or chiseled to reduce compaction and bring soil clods to the surface to prevent soil from blowing. Sometime before seeding, most land is listed to further reduce soil-blowing and provide a well-drained seedling environment if the soil is wet at seeding. Preplant herbicides are often incorporated with a tandem disk before listing.

Planting methods and equipment

Dryland cotton is commonly planted on a bed with unit planters in the loam and clay loam soil areas. Both bed and furrow planting are used in the fine sandy loam areas. Furrow planting with a lister planter is most common in loamy fine sand areas. With the lister planter, a chisel or runner opener behind the lister point opens a slot for placing the seed 1.5 to 2 inches deep in the bottom of the furrow. A press wheel, operated immediately behind the opener, presses seed into the bottom of the furrow. A drag covers the seed with moist, loose soil.

Cotton emerges better when planted in a broad, shallow-listed furrow than when planted in a deep furrow (Colwick 1957, Elliot et al. 1968). Deep furrows provide seedlings with protection against soil-blowing, which frequently occurs on sandy soils. However, deep furrows are conducive to "washing in," which can cover seedlings when high intensity rainfall occurs. Furrows must be deep enough so that seed are placed in moist soil; thus, in dry years it is necessary to have deeper furrows. When the soil is wet at planting, listers may be operated at shallow depths. Frequently, herbicides are sprayed in bands behind the planter, with shallow incorporation by vertical fingers or rotary hoes mounted behind the openers.

Double-disk-opener unit planters are also used to plant cotton on flat ground or on top of listed beds when the soil is moist near the surface. Sweeps or shovels are frequently operated

in front of the planter to kill weeds and loosen the soil.

Plant population and row spacing

Plant populations for dryland cotton are not critical. Colwick (1957) reported that 40,000 plants per acre are optimum for southwest Oklahoma and west Texas, but populations could vary between 30,000 and 50,000 plants per acre with little or no effect on yield. N. B. Thomas (personal communication) at Altus, Okla., and D. W. Fryrear (personal communication) at Big Spring, Tex., recommended a population of 44,000 plants per acre for solid planting (40-inch row spacing). This is a plant spacing of 3 to 5 inches within planted rows. With this plant spacing, populations would be less for skip-row systems than for solid row planting. Low populations should be avoided when soil water is favorable because, when low populations are grown under this condition, plants grow large and are difficult to harvest.

Cotton is normally seeded in 40-inch spaced rows. However, it can be produced successfully with row spacings of 10 to 20 inches. At Lubbock, Tex., Hudspeth and Brashears (1974) reported that cotton seeded in 40-inch rows and 10-inch rows produced similar yields when the population was 50,000 plants per acre or less and when average rainfall occurred. However, yields were significantly higher with narrow rows when precipitation was above average and plant populations were increased to 100,000 plants per acre. Short-season cotton varieties adapted to narrow-row planting have been developed, but in dry years the plants are short and harvesting is difficult. Also, herbicides must be 100 percent effective or hand-hoeing will be required because postplant cultivation of narrow-row cotton is difficult.

Grain Sorghum

General cropping practices

Sorghum is well adapted to dryland grain production in the Southern Great Plains. The periods of peak water use by sorghum and naturally occurring high summer rainfall frequently coincide to produce high sorghum grain yields. When water stress occurs during drought periods, sorghum growth slows and becomes practically dormant. Plants resume growth when sufficient soil water is again available; thus, sorghum usually produces some grain, even under adverse moisture conditions (Leonard and Martin 1963).

The heaviest concentration of sorghum production is on coarse-textured soils in the Southern High Plains, where it is rotated with cotton, and in the Oklahoma Panhandle, where sorghum may be seeded if the soil was too dry to seed wheat the preceding fall (fig. 4). Sorghum is the major dryland cash crop only on small areas of sandy soil in the northern portion of the Texas Panhandle and the Oklahoma Panhandle.

Sorghum uses stored soil water efficiently (Brown and Shrader 1959, Jones and Hauser 1974). However, yields are not increased sufficiently by fallowing to justify a sorghum-fallow

Table 2.—Annual grain sorghum yields, in pounds per acre, in the Southern High Plains land-resource area[1]

Cropping sequence	Bushland 1959-72[2]	Dalhart 1909-38[3]	Lubbock 1914-40[4]	Big Spring 1916-53[5]
Wheat-sorghum-fallow	1,690	.....	.....	.....
Continuous sorghum	1,110	1,230	1,220	1,120
Fallow-sorghum	.....	1,980	1,590	1,480
Cotton-sorghum	.....	.....	1,490	650

[1]All four locations are in Texas.
[2]Jones (1975).
[3]Mathews and Barnes (1940).
[4]Harvey et al. (1961).
[5]Keating and Mathews (1957).

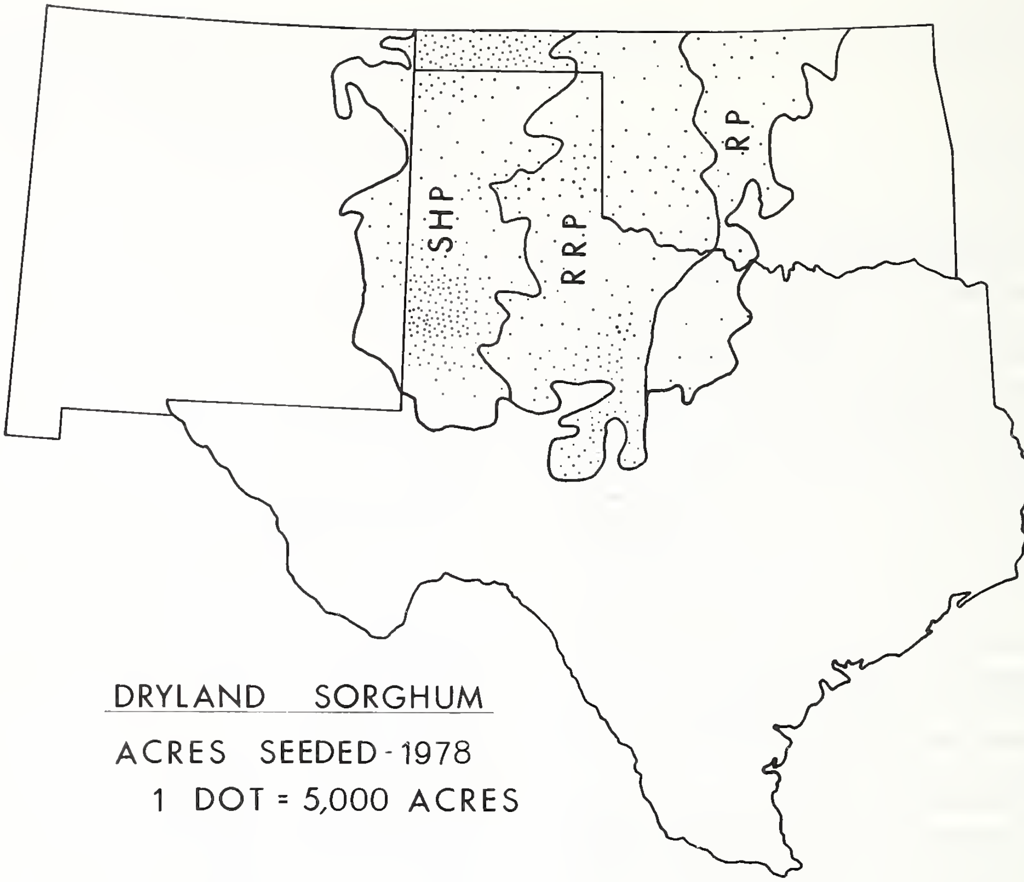

FIGURE 4.—Distribution of dryland sorghum in the Southern High Plains (SHP), Rolling Red Plains (RRP), and Reddish Prairie (RP) land-resource areas of the Southern Great Plains. (Drawn from data supplied by Crop and Livestock reporting services of Texas, Oklahoma, and New Mexico.)

cropping system, which has a 19-month fallowing period (Harvey et al. 1961, Mathews and Barnes 1940, Fryrear 1976). In the Rolling Red Plains at Woodward, Okla., sorghum yields from continuous cropping and cropping after fallow were equal (Locke and Mathews 1953). Yields of continuously cropped sorghum are lowest in the western areas and increase eastwardly in response to greater average annual precipitation. Grain yields of continuous sorghum are low in the Southern High Plains (table 2); thus, in drier areas sorghum is best utilized in a wheat-sorghum-fallow sequence or possibly a cotton-sorghum sequence. Since cotton normally does not leave soil as depleted of moisture and nutrients as sorghum, sorghum yields after cotton usually are as great as yields from continuous sorghum unless they are influenced by adverse cultural practices. This is demonstrated by the results obtained at Lubbock (table 2). Keating and Mathews (1957) did not explain the extremely low sorghum yields obtained with the cotton-sorghum sequence at Big Spring. These low sorghum yields may have been related to increased wind erosion following the cotton.

Seeding date

Sorghum may be planted from the time the soil warms to 60° F in the spring until the latest date that will allow plants to reach physiological maturity before frost. Major factors that determine seeding date are sorghum hybrid maturity group, soil temperature, seasonal rainfall and temperature patterns, diseases, and insects.

Quinby et al. (1958) reported that sorghum

planting can begin in the Southern High Plains about May 15, but higher yields are produced from plantings made June 10–25. However, to avoid sorghum midge, *Contarinia sorghicola* (Coquillet), infestations in the southern part of the Southern High Plains, sorghum should be seeded so that blooming occurs before August 1. Short-maturity hybrids should be planted before June 10, and longer season hybrids should be seeded earlier (Bottrell 1971).

In the Rolling Red Plains of Texas, similar grain yields result from plantings made in April, May, or June. However, during some years economic infestations of sorghum midge occur in sorghum blooming after July 15. Sorghum midge can be controlled with insecticides. It is seldom observed north of the 35th parallel (E. P. Boring, personal communication).

Seedbed preparation

The residues of the previous crop should be left on the soil surface over winter to aid in wind erosion control. In early spring, residues should be undercut with V-shaped blades or chiseled to loosen the soil and cover seed from the previous crop so that volunteer plants and weeds emerge before seeding. The initial tillage operation should be deep enough to establish a loose, friable seedbed, with subsequent operations at shallower depths. On coarse-textured soils, listing is desirable to prevent or reduce wind erosion. On fine-textured soils, the surface is normally left flat until seeding. Before seeding, shallow tillage with rod weeders or sweeps is usually necessary to kill weeds and volunteer plants. Preemergence herbicides can be applied at planting or anytime before seedling emergence. Broadleaf weeds can be controlled in most sorghum hybrids by applying 2,4-D after the plants are at least 6 inches tall.

Planting methods and equipment

Sorghum can be seeded with a grain drill, lister planter, or unit planter. Lister planters are commonly used where cotton is grown, and unit planters or grain drills, either disk or deep furrow, are used elsewhere. Spouts on grain drills can be plugged to achieve desired row spacings.

Plant population and row spacing

Sorghum is grown as a row crop. When water is adequate, as is often the case in the Rolling Red Plains and the Reddish Prairie, sorghum yields are increased by seeding in narrow rows (20- to 30-inch row spacings). Yield increase with narrow rows in comparison to yields with the wider 40-inch rows is attributed to more efficient use of water, nutrients, and solar energy (Onken 1971). With limited water at Bushland in the Southern High Plains, Bond et al. (1964) achieved significantly higher production with 40-inch row spacings than with 20-inch row spacings. They also found that a 2.0 pound-per-acre seeding rate produced higher yields than a 4.0 pound-per-acre seeding rate. Brown and Shrader (1959) obtained similar results at Hays, Kans. They attributed higher yields with wide row spacings to increased competition within the row, which reduced water use during early growth stages. They found that the competition reduced forage production but increased grain yield and water-use efficiency for grain production.

Sorghum produces the same yield over a wide range of plant populations owing to adjustments in plant head size and number of tillers. High plant populations with limited water, however, may increase early-season use of soil water and subsequently cause late-season water stress, resulting in reduced yield and increased lodging (Onken 1971). Minimum seeding rate for limited water is about 2.0 pounds per acre or a population of 25,000 plants per acre. Seeding rates can be increased in response to increased water supplies.

Forages

Forages commonly grown on cultivated dry land in the Southern Great Plains are alfalfa, *Medicago sativa* L.; sorghums; and small grains. Alfalfa is normally grown only in areas of 25 inches or more annual rainfall (Hughes et al. 1962). Alfalfa production in the Southern Great Plains is limited to the eastern half of the Rolling Red Plains and to the Reddish Prairie. On fine-textured soils in north central Oklahoma, most alfalfa is grown for hay. Yields average about 4 tons per acre (D. Fain, personal

communication). Stands are commonly maintained for 5 to 8 years. In southwestern Oklahoma on coarser textured soils, alfalfa is grown primarily for seed. Each year, one or two hay crops are harvested, and then the crop is allowed to produce seed. Seed yields are low, ranging from about 150 to 180 pounds per acre. Stands are normally maintained for 4 or 5 years, followed by wheat for several years (N. B. Thomas, personal communication).

Seedbed preparation for dryland alfalfa is critical because seed must be sown shallow (0.5 inch), yet be placed in moisture. A fine, firm seedbed is obtained by moldboard-plowing, disking, and cultipacking. Single- or double-disk grain drills are used to seed 12 to 20 pounds per acre of seed inoculated with *Rhizobium meliloti* (Dangeard). Most alfalfa is seeded in August and September, thus annual weeds that emerge after seeding are killed by frost. Alfalfa seeded on land infested with perennial weeds will not succeed. A 3-year supply of phosphorus (about 50 pounds per acre) is commonly "plowed down" at establishment.

Maintenance of the alfalfa stand is enhanced by allowing plants to bloom before cutting for hay. Frequent cutting at immature stages increases hay quality but weakens stands, reduces yields, and encourages growth of weeds and grasses. Alfalfa should be cut high enough above the ground so that some leaves remain and basal buds are preserved to promote rapid regrowth (Arnon 1972).

Sorghum forages are frequently grown for grazing, with excess production being baled for hay. Sudangrass, *Sorghum sudanense* (Piper) Hitchc., hybrids and sweet sorghum, *Sorghum bicolor* (L.) Moench, × sudangrass hybrids are best adapted because they are fine-stemmed and leafy (Doggett 1970). Sorghum forages are seeded with equipment that is readily available on the farm. Where wheat is the primary crop, grain drills are frequently used, and in other areas, lister or unit planters can be used. Seedbed preparation is similar to that used for grain sorghum or cotton.

Small grains, particularly winter wheat, provide important sources of forage for grazing. Winter wheat is grazed extensively whenever water is sufficient for early growth. Wheat can be grazed until near jointing in the spring without seriously reducing grain yields if adequate nutrients are provided. Yields of 0.3 to 0.4 ton per acre of air-dried forage are common for winter wheat in western and central Oklahoma (Hubbard and Harper 1949, Huffine et al. 1960).

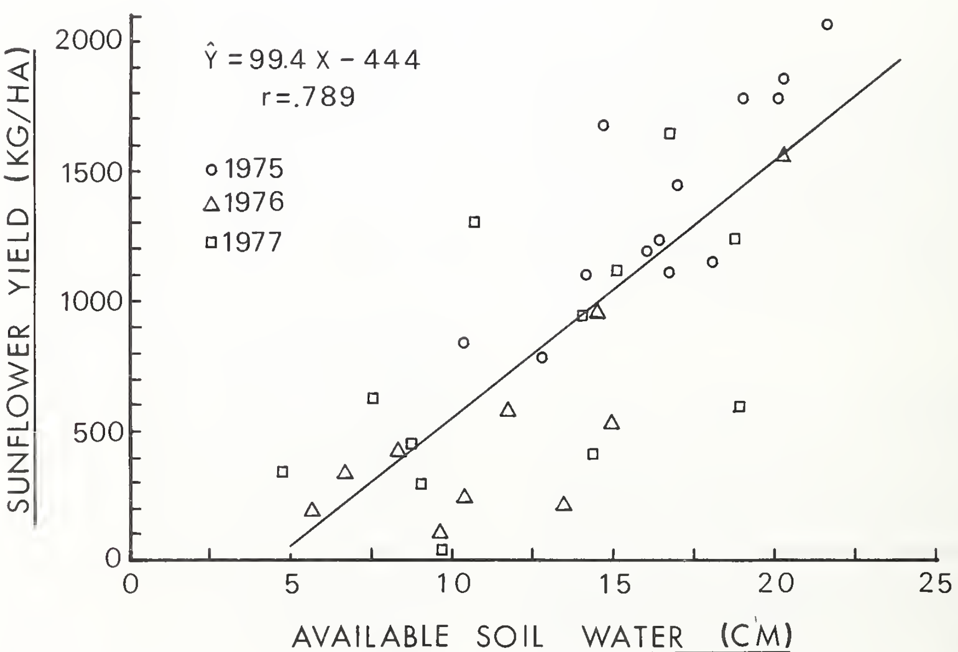

FIGURE 5.—Effect of soil-water content at seeding (zero to 6-foot soil depth) on seed yield of dryland sunflowers (Jones 1978).

With ideal conditions, maximum grazing yield may approach 1.0 ton per acre of air-dried forage.

Other small grains that are frequently seeded for forage are rye, *Secale cereale* L.; oats, *Avena sativa* L.; and winter barley, *Hordeum vulgare* L. However, the total area seeded is small, amounting to about 7 percent of the area seeded to wheat.

Sunflowers

Commercial sunflower production began in the Southern Great Plains in 1975. Approximately 75,000 acres of oilseed sunflowers were grown in Texas in 1979, with most production being in the Southern High Plains. Significant production was also recorded in New Mexico and Oklahoma. Although much of the sunflower acreage is irrigated, the crop is also successfully grown in dryland areas (Jones 1978). Drought tolerance of sunflowers is attributed to their extensive root system, which can extract water and nutrients to soil depths of 9 feet. Thus, on deep soils with a high water-holding capacity, water stored at planting can provide much of the water requirement of sunflowers. The effect of soil-water content at planting on seed yield of dryland sunflowers is shown in figure 5. High soil-water content at planting can be attained on dry land by fallowing or conservation benching (Jones 1975).

Sunflowers are adapted to a wide range of soil types and can be grown on most of the cultivated soils in the Southern Great Plains. Total area seeded to sunflowers has been limited by diseases, insect problems, and economic competition from other summer crops, primarily sorghum and cotton.

Sunflowers are grown in row widths of 30 to 40 inches. Land preparation and planters are the same as for cotton or sorghum. Sunflowers can be grown over a wide range of plant populations with little effect on yield. Populations of 10,000 to 14,000 plants per acre are adequate for dryland production. Thick stands can result in lodging, and thin stands are difficult to harvest because stalks and heads are large. Standard grain combines with commercially available sunflower heading attachments are used to harvest sunflowers (Allen et al. 1979). Row-crop headers also work well (fig. 6).

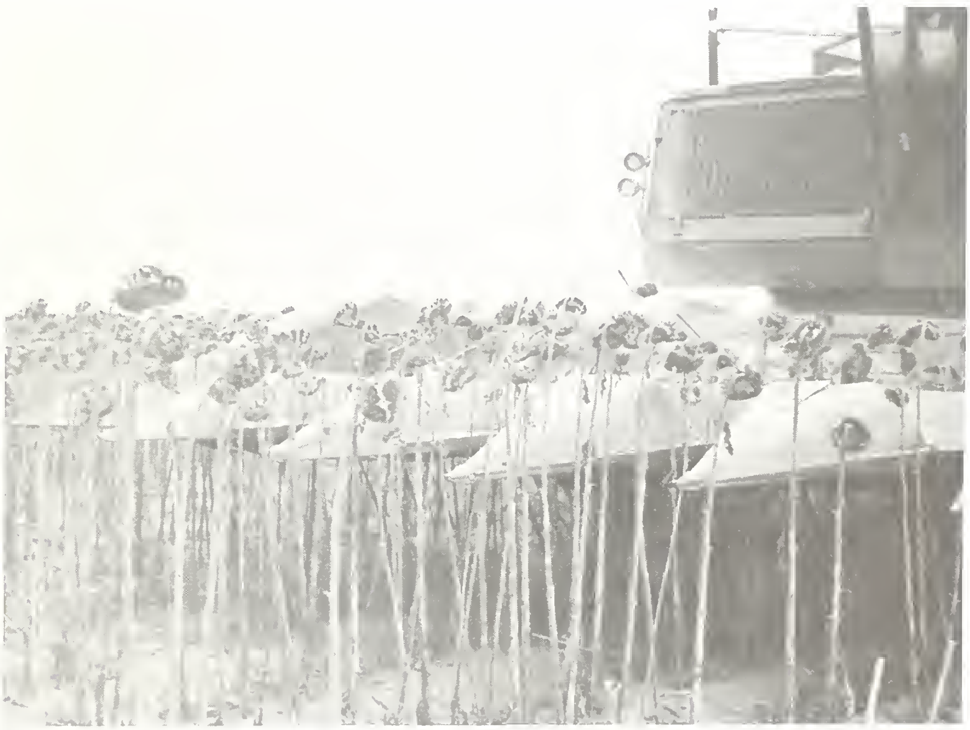

Figure 6.—Harvesting sunflowers with combine equipped with row-crop header.

One advantage of sunflowers over sorghum or cotton is that a wide range in seeding dates is possible, since seedlings are frost-resistant and mature heads are seldom damaged by freezes. Thus, sunflowers can be seeded from early April until mid-July. Although seed yields and total oil content are reduced by late seeding (June-July), fewer insect and disease problems are encountered. Sunflowers can be successfully grown after hailed-out cotton, since herbicides for the two crops are compatible.

Sunflowers have the reputation of being "hard" on soil, and yields of crops following them are frequently reduced because sunflowers dry the soil profile to much greater depths than most other crops. This indicates that sunflowers can be included in crop sequences to utilize water and nutrients that have accumulated below the normal rooting depth of most crops. In the Southern High Plains, many farm operators that have limited irrigation water supplies are alternating irrigated sorghum with dryland sunflowers.

Guar

Guar is a summer annual legume grown primarily for its seed (fig. 7). The endosperm of guar seed is high in galactomannan gum, which is an important industrial gum. Production of guar is centered in the Rolling Red Plains of Texas and Oklahoma, with about 100,000 acres being grown annually (Tripp et al. 1977).

Guar is drought-resistant. Growth stops or slows when water is limited and resumes when moisture is again available. Guar is best adapted to well-drained sandy or sandy loam soils, since it cannot tolerate flooding. Guar is usually grown in rotation with cotton, since herbicide requirements for the two crops coincide and the lint yield of cotton following guar may be greater than that of cotton following cotton. Mulkey (1971) found that yields of cotton following guar were 22 percent greater than those of cotton following cotton. Guar can also be interplanted with cotton grown in skip-row cropping systems.

Seedbed preparation and planting methods are similar to those used for cotton. Guar is usually seeded in 40-inch rows at a rate of 4 to 6 pounds per acre. The row surface should be above general ground level to facilitate harvest. Guar may be seeded in the Rolling Red Plains between May 15 and July 1. Early seeding is preferred, because with late seeding fall rains frequently reduce seed quality. Guar is harvested with a grain combine (Tripp et al. 1977).

FIGURE 7.—Guar in the Rolling Red Plains near Vernon, Tex. Dr. Roy Stafford (ARS) is comparing branching growth common to most guar varieties (right) with new varieties having non-branching growth (left).

CROPPING SYSTEMS

Crops and cropping systems differ as soils, environment, and economic situations change. Useful cropping systems must obtain maximum efficiency of water and nutrient use as well as conserve water and soil resources for future production. Most cropping systems currently employed in the Southern Great Plains result in efficient water and nutrient use and provide wind and water erosion protection when suitable conservation practices are employed. A notable exception is the continuous cotton production in sandy areas of the

Southern High Plains, where it is much more profitable to grow continuous cotton than use a cotton-sorghum or other crop sequence.

Continuous winter wheat is the prevalent cropping system in the northern part of the Rolling Red Plains and in the Reddish Prairie. Grain sorghum, alfalfa, and other forages are frequently grown, but areas planted to these crops are small in comparison to the area planted to wheat. Thus, only a small portion of the area can be rotated from wheat to other crops each year. In the southern part of the Rolling Red Plains, wheat is frequently rotated with cotton. The crops, however, are not seeded in alternate years because a 10- to 11-month fallowing period is required between these crops, which reduces production. Thus, wheat is grown for 3 or 4 years in succession before rotating to cotton, which is also grown for several years in succession. Guar is sometimes rotated with cotton, but the total area of guar is small compared to the area seeded to cotton and wheat.

Continuous upland cotton is the prevalent dryland cropping system in the southern part of the Southern High Plains. Some areas on coarser soils are seeded only to cotton, which creates a wind erosion problem. However, the high economic return of cotton in comparison to sorghum, the other adapted crop, results in cotton being grown exclusively, regardless of severe wind erosion problems. Tillage is used for emergency wind erosion control on cotton land. On the drier western edges of the region near the Texas-New Mexico State line, both sorghum and cotton are grown. However, there seldom are fixed rotations between the crops. Frequently, sunflowers are seeded after cotton has been "blown out" by sand or destroyed by hail. On finer textured soils, a flexible cropping system that includes winter wheat is used. Wheat is grown in a cotton or sorghum-fallow-wheat sequence. If soil-water conditions are favorable in the fall after wheat harvest, wheat is seeded again. If soil-water conditions are poor, the land is fallowed and seeded to cotton or sorghum the following spring. Preferential treatment is given to cotton, the high-value crop, with large areas being seeded when soil-water conditions are favorable. Wheat is frequently grown as a winter forage crop.

Continuous wheat or wheat-fallow are the prevalent cropping systems in the northern part of the Southern High Plains. Normally, if soil-water conditions are favorable at seeding, wheat is planted. If conditions are poor, the land is fallowed and planted to wheat the following year. Thus, the area fallowed varies from year to year, depending on the amount of rainfall between wheat harvest and seeding. A wheat-sorghum-fallow sequence is also adapted to this region. This system has 11 months of fallow preceding each crop and results in one wheat and one sorghum crop in 3 years. Continuous sorghum is prevalent on small areas of sandy soil in the northwest counties of the Texas Panhandle and in the Oklahoma Panhandle. The total area seeded continuously to sorghum is small in comparison to the area seeded to wheat.

PROMISING RESEARCH DEVELOPMENTS

Unger and Phillips (1973) proposed growing irrigated and dryland crops alternately in the same areas, using the high levels of residue remaining after the irrigated crop to increase water storage for dryland crop production. Unger and Wiese (1979) grew wheat and sorghum in an irrigated wheat-fallow-dryland sorghum cropping sequence using different tillage systems. The average fallowing efficiency during the 11-month fallow period preceding dryland sorghum was 35 percent with no tillage, compared to 15 percent for disk tillage. Subsequent yields of dryland sorghum were 2,800 pounds per acre with no tillage, compared to 1,720 pounds per acre with disk tillage. The yield increase was attributed to increased soil-water storage during fallow, which resulted from high levels of crop residue on the surface with the no-tillage system. With large areas of the Southern High Plains currently receiving limited irrigation and with the irrigated area projected to decline, ample opportunity exists for use of alternate irrigated-dryland cropping systems.

No tillage and limited tillage (systems that use herbicides to replace tillage) are becoming common on dry land in the Southern Great Plains. Herbicides, primarily atrazine and 2,4-D, can control weeds on fallow after wheat more economically than tillage (A. F. Wiese, personal communication). Similarly, weeds in

cotton can be controlled more economically with herbicides than by tillage and hand-hoeing. Rising fuel and labor costs, relative to herbicide costs, have improved the economics of weed control with herbicides.

Dryland crop yields can be increased by managing storm runoff, either by collecting storm runoff on leveled areas or by adopting conservation practices to retain all precipitation on the field. Jones and Hauser (1974) reported that continuous sorghum yields for 1959-72 were 1,110 pounds per acre for a 1-percent slope, 1,590 pounds per acre for bench terraces, and 2,000 pounds per acre for conservation bench terraces that received an average runoff contribution of 2.7 inches per year from adjacent watersheds. Jones and Shipley (1975) reported that construction of bench-terrace or conservation-bench-terrace systems to control runoff could be profitable. Subsequent research by Jones (1981) showed that any conservation practice that retained runoff in place, such as bench-terracing or contour-listing, increased yields of continuous sorghum by 50 percent in comparison to yields from graded furrows on a 0.25 percent slope.

Another water conservation practice that has come into widespread use recently in the Southern High Plains is furrow-diking (figs. 8 and 9), with more than 1 million acres being furrow-diked in 1980 (E. B. Hudspeth, personal communication). Bilbro and Hudspeth (1977) reported that furrow-diking retained runoff and increased cotton lint yields by 15 percent at Lubbock. At Bushland in 1977, furrow-diking increased grain sorghum yields by 47 percent, an increase of 700 pounds per acre (Clark and Jones 1981). Lyle and Dixon (1977) discussed the history and concepts of furrow-diking.

FIGURE 8.—Runoff conservation with furrow dams on dryland sorghum at Bushland, Tex., 1978.

RESEARCH NEEDS

The authors believe that major research efforts in dryland agriculture in the Southern Great Plains should be directed towards the following:

1. Introducing additional crops that can economically compete with wheat and cotton on dry land to provide increased flexibility in cropping systems.

2. Developing adapted cultivars with improved photosynthetic efficiency to utilize water and nutrients more efficiently for crop production.

3. Developing new and improved dryland cultural and management practices that will increase crop yields and conserve and use soil and water resources efficiently.

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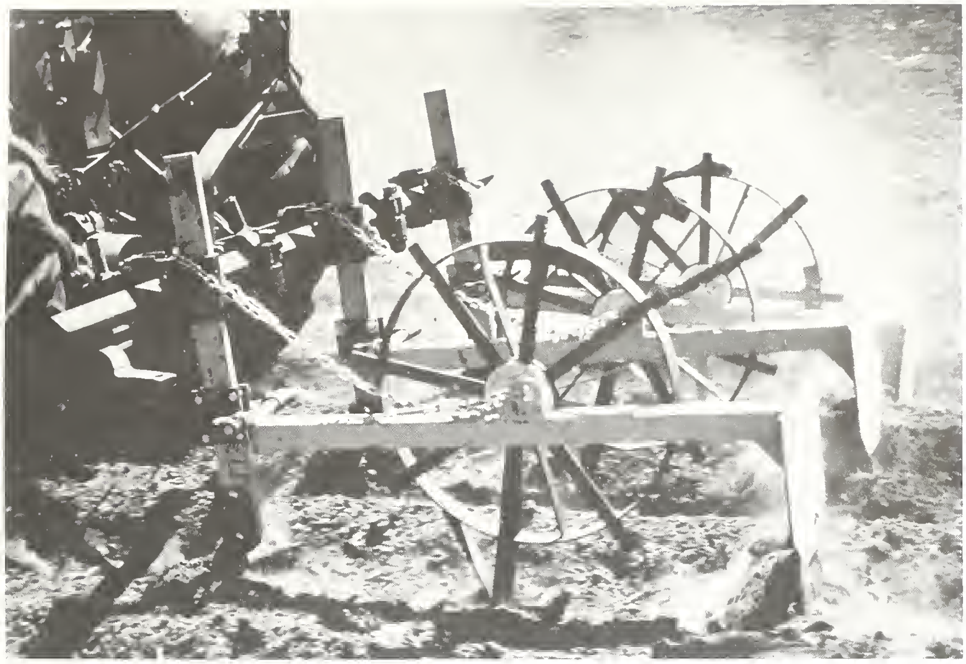

FIGURE 9.—Equipment used to construct furrow dams.

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APPENDIX.—NOMENCLATURE OF HERBICIDES

Common name	Trade name	Chemical name
Atrazine	Aatrex, Atrazine	2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine.
Glyphosate	Roundup	*N*-(phosphonomethyl) glycine.
Nitralin	Planavin	4-(methylsulfonyl)-2,6-dinitro-*N*,*N*-dipropylaniline.
Trifluralin	Treflan	α,α,α-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine.
2,4-D	2,4-D	(2,4-dichlorophenoxy) acetic acid.

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